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IMBALANCE OF THE EARTH SYSTEM IN TERMS OF ENTROPY

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ABSTRACT

The Earth system consists of many interacting geospheres (e.g., atmosphere, hydrosphere, biosphere, lithosphere, pedosphere, cryosphere), each of which is further composed of interacting subsystems over a wide range of scales. The mainstream approach to tackle this complex system relies on earth system modeling (ESM) that is based on various conservation principles (e.g., conservation of energy, mass and momentum), breaks the Earth system into ever smaller units, and includes ever more processes. Despite the great progress over the last few decades, the bottom-up ESM approach still suffers from many deficiencies such as highly uncertain climate sensitivity and cloud feedbacks.

This study explores a new theoretical framework that treats the Earth system as a whole and seeks entropy-based principle in addition to those conservation principles (e.g., energy conservation). In particular, we show that even at steady state, radiation entropy is highly imbalanced, with the outgoing longwave radiation carrying much more radiation entropy than the incoming solar radiation, and that the Earth system as a whole works to maximize the radiation entropy imbalance by building close connection between incoming shortwave and outgoing longwave radiation. The entropy-based theory provides a possible explanation of why the Earth albedo varies around 0.3 during the Holocene.